Higgs in gluon–gluon fusion: follow-up

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(J.B. and A. Djouadi, work in progress)

Gluon–gluon fusion Higgs production at the Tevatron (SM)

$gg \to H$ at the Tevatron; follow J.B and A. Djouadi (arXiv:1003.4266)

Start with HIGLU (M. Spira):

Exact at LO[a] and NLO QCD[b],

$K_{\rm NLO} \sim 2$

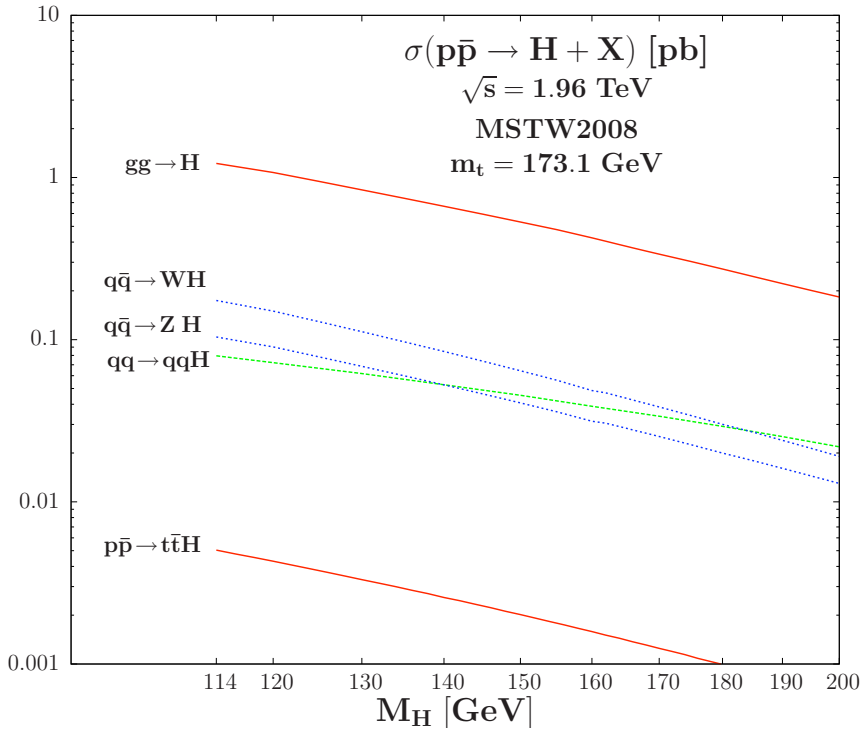
And include relevant HO corrections:

EFT at NNLO QCD[c], $K_{\rm NNLO} \sim 3$

Exact NLO EW corrections[d]

+EFT NNLO mixed QCD-EW[e]

$\simeq$ a few % for both corrections.



[a] Georgi, Glashow, Machacek & Nanopoulos (1978).

[b] Djouadi, Spira & Zerwas (EFT, 1991); Dawson (EFT, 1991); Spira, Djouadi, Graudenz, Zerwas (exact, 1995).

[c] Harlander & Kilgore (2002), Anastasiou & Melnikov(2002), Ravindran, Smith & van Neerven (2003).

[d] Actis, Passarino, Sturm& Uccirati (2008).

[e] Anastasiou, Boughezal, Pietriello (2009).

Scale variation at $\mu_0 = M_H/2$

One important point of arXiv:1003.4266: errror obtained with μ_R, μ_F independant variation around central $\mu_0 = M_H$:

$$M_H/\kappa \leq \mu_R, \mu_F \leq \kappa M_H,\ \kappa = 3$$

1. We accept the point that $\mu_0 = M_H/2$ is a more appropriate central scale [see B. Anastasiou talk] and we redo our analysis.

   No more difference between NNLL and NNLO central cross sections.

2. Scale uncertainty: we assure $\frac{1}{3}\left(\frac{M_H}{2}\right) \leq \mu_R = \mu_F \leq 3\left(\frac{M_H}{2}\right)$

   $\mu_R \neq \mu_R$ irrelevant as $\max \sigma(\mu) = \sigma(\mu_R = \mu_F = M_H(/2)/\kappa)$
   $\min \sigma(\mu) = \sigma(\mu_R = \mu_F = \kappa M_H(/2))$

   Keep $\kappa = 3$ as for σ^{LO} band to catch σ^{NNLO}

$$\sigma^{\mathrm{NNLO}}_{gg\to H} : \simeq +15\%, -20\% \text{ scale variation}$$

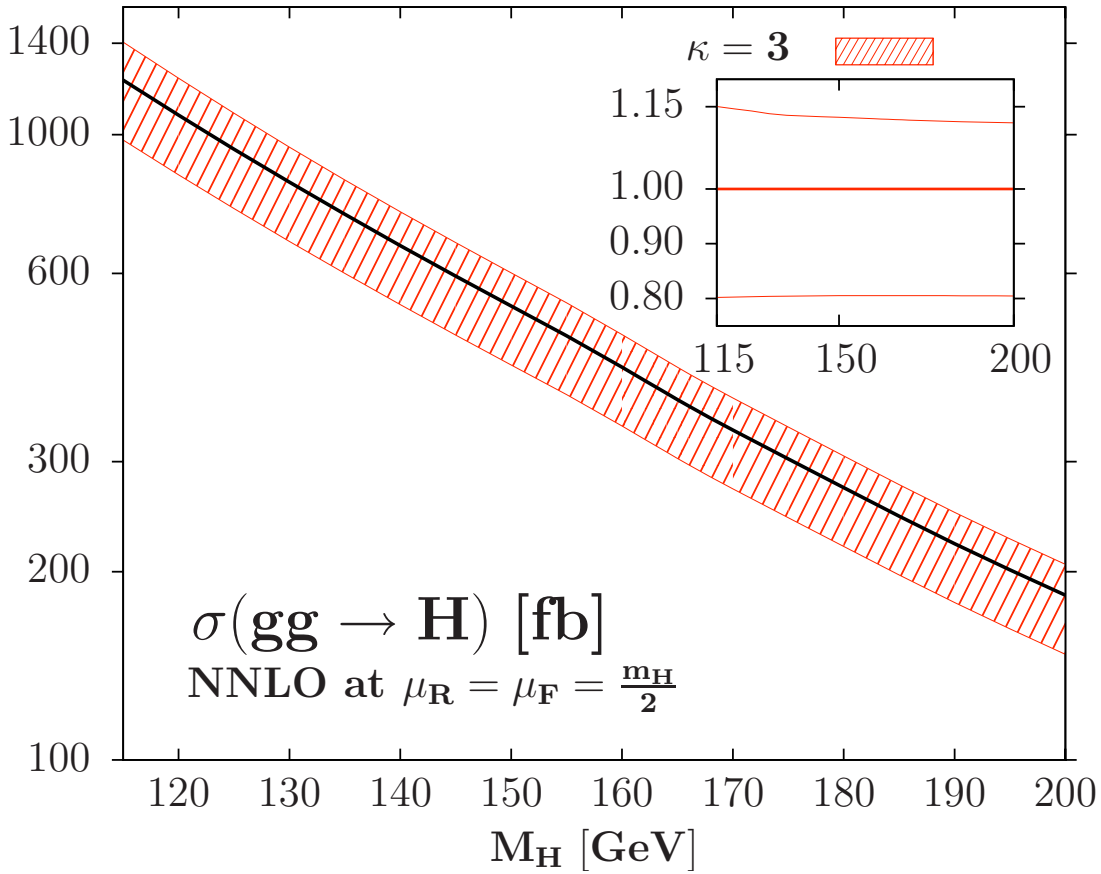
Good agreement with H+jets analysis (Anastasiou et al., arXiv:0905.3529):

$$\frac{\Delta N_{\mathrm{signal}}(\mathrm{scale})}{N_{\mathrm{signal}}} = 60\% \cdot \begin{pmatrix} +5\% \\ -9\% \end{pmatrix} + 29\% \cdot \begin{pmatrix} +24\% \\ -23\% \end{pmatrix} + 11\% \cdot \begin{pmatrix} +91\% \\ -44\% \end{pmatrix} = \begin{pmatrix} +20.0\% \\ -16.9\% \end{pmatrix}$$

Only $\Delta\sigma \simeq \pm 12\%$ with $\kappa = 2 \Rightarrow$ not enough to reproduce H+jets analysis.

Scale variation at $\mu_0 = M_H/2$

$\sigma^{\rm NNLO}_{gg\to H}$: $\simeq$ **+15%, −20% scale variation**



PDFs+α_s uncertainties and EFT

1. PDF+$\Delta^{\rm exp+th}\alpha_s$:

   PDFs only: $\simeq \pm 8\%$ with MSTW set, **25% discrepency with other sets (ABKM)**

   Use MSTW PDF+$\Delta^{\rm exp}\alpha_s$ correlations set$\Rightarrow$ 14% at 90%CL, still discrepency with ABKM

   Include $\Delta^{\rm th}\alpha_s^{\rm NNLO} = 0.002$ with MSTW fixed-α_s central sets, reconcile both sets

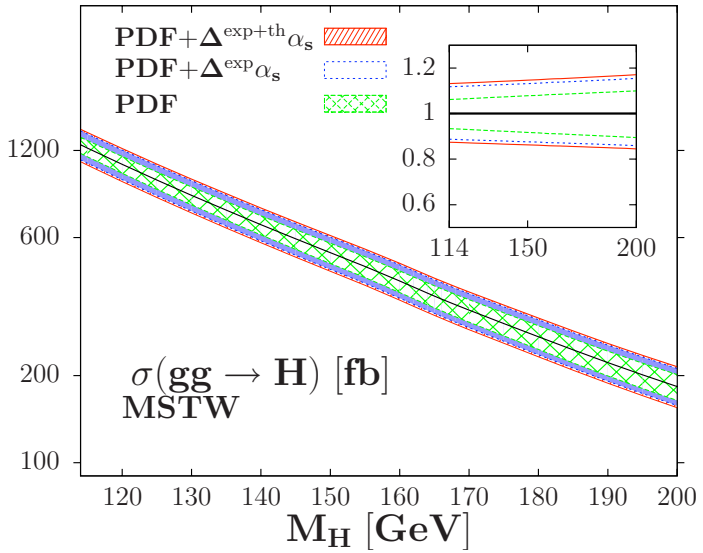
   $\alpha_s^{\rm ABKM} = 0.1147 \pm 0.0012({\rm exp}) \pm 0.002$ (**th**)
   consistent with N^{3}LO analysis (hep-ph/0607200)

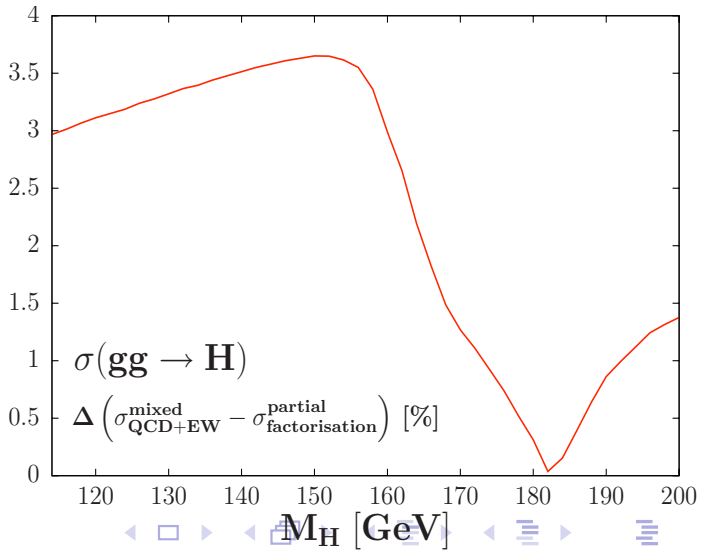
   $\sigma^{\rm NNLO}_{gg\to H}$: $\simeq$ **13 – 15% error from PDFs**

2. EFT error at NNLO: few **(non-negligible) %**

   Missing b–loop at NNLO and ($m_b^{\rm OS,\overline{MS}}$)

   Error on mixed QCD–EW corrections



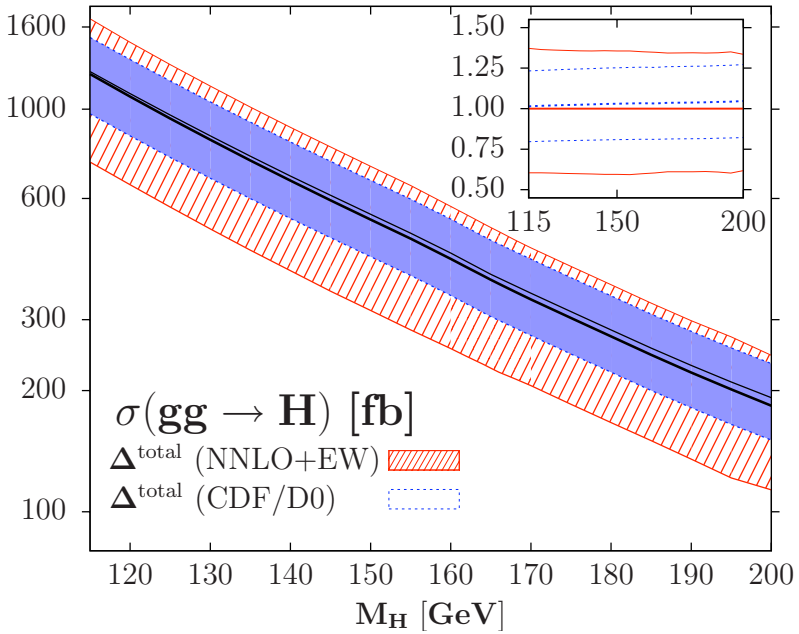


Tevatron result with combined errors

Method for combination: apply PDF+$\Delta^{\rm exp+th}\alpha_s$ on $^{\rm min}_{\rm max}\sigma(\mu)$ then add linearly the small EW and b–loop errors.

Final error in gg $\to$ H : $\sim \pm 38\%$

Only slightly less than our previous analysis: $+50\%, -40\%$ **but with a** $+10\%$ **increase of the central cross section**



Newest Tevatron exclusion band (arXiv:1007.4587) still debatable

Gluon–gluon fusion Higgs production at the ℓHC (SM)

$gg \to H$ at ℓHC (LHC with 7 TeV and 1 fb^{-1})

Start with HIGLU (M. Spira):

Exact at NLO QCD[a], $K_{\rm NLO} \sim 1.9$

And include relevant HO corrections:

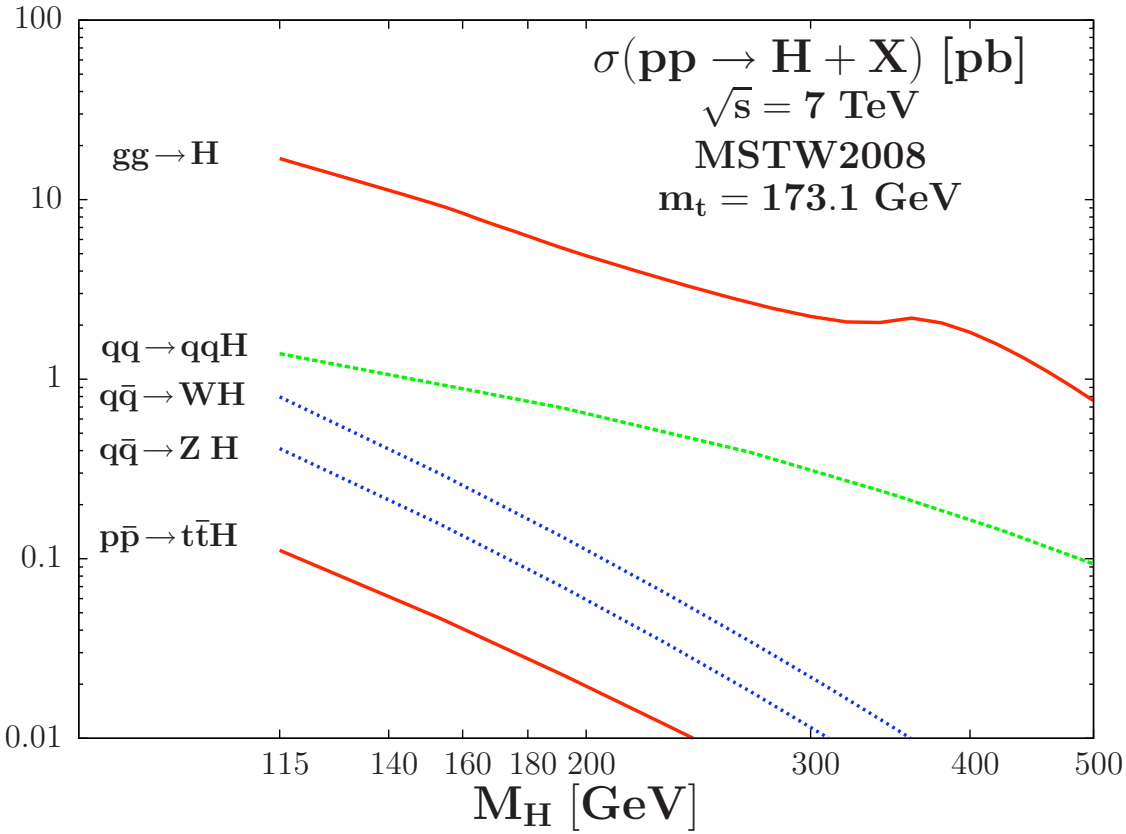
EFT at NNLO QCD[b], $K_{\rm NNLO} \sim 2.5$

(NNLL: $\approx +10\%$ not included)[c]

Exact NLO EW corrections[d]

+EFT NNLO mixed QCD-EW[e]

$\simeq$ a few % for both corrections.



[a] Djouadi, Spira & Zerwas (EFT, 1991); Dawson (EFT, 1991); Spira, Djouadi, Graudenz, Zerwas (exact, 1995).
[b] Harlander & Kilgore (2002), Anastasiou & Melnikov(2002), Ravindran, Smith & van Neerven (2003).
[c] Catani, de Florian, Grazzini & Nason (2003). [d] Actis, Passarino, Sturm& Uccirati (2008).
[e] Anastasiou, Boughezal, Pietriello (2009).

Scale variation and PDFs+α_s uncertainties

Following JB+Djouadi, arXiv:1003.4266

Scale variation: obtained with μ_R, μ_F variation around central $\mu_0 = M_H$:

$$M_H/\kappa \leq \mu_R, \mu_F \leq \kappa M_H$$

$\kappa = 2$ enough at ℓHC

$\sigma^{\rm NNLO}_{gg\to H}$: $\simeq$ **+13%, −10% scale variation**

PDF+$\Delta^{\rm exp+th}\alpha_s$:

use MSTW PDF+$\Delta^{\rm exp}\alpha_s$ correlations set

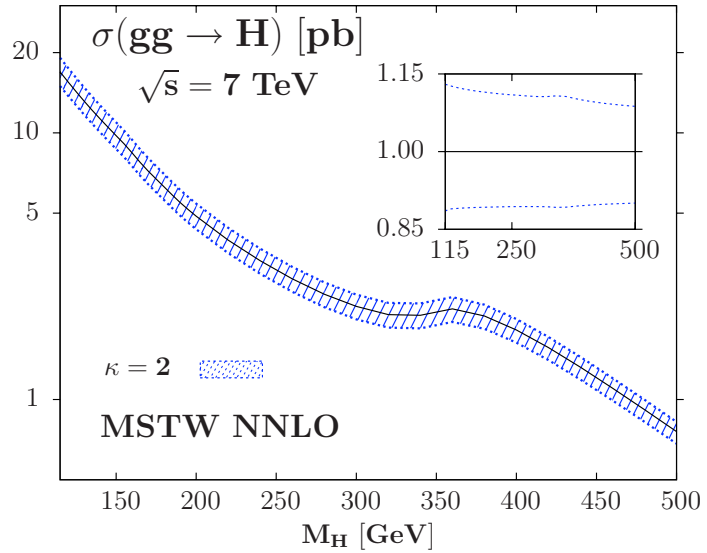
$\Delta^{\rm th}\alpha_s^{\rm NNLO} = 0.002$ with MSTW fixed-α_s central sets

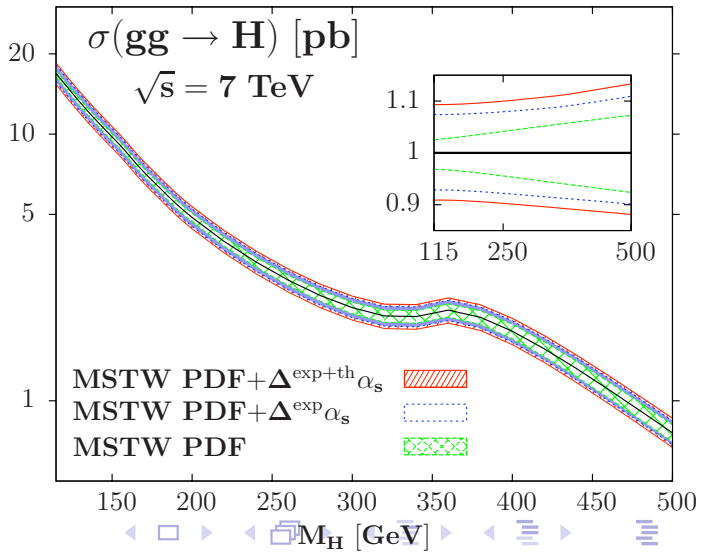
$\sigma^{\rm NNLO}_{gg\to H}$: $\simeq$ **10 − 13% error from PDFs**

Error from use of EFT at NNLO: few %

Missing b–loop at NNLO and $(m_b^{\rm OS,\overline{MS}})$

Error on mixed QCD–EW corrections





ℓHC result with combined errors

Method for combination: Same as in previous section

Final error in gg $\to$ H : $\sim -25\%$, $\sim +30\%$

much more under control than at Tevatron: $\sim -40\%, +50\%$ error

in our previous analysis, $\simeq \pm 38\%$ in the latest